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Our Clothes, New for Old

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Abstract: This paper deals with the significances and changes that may take place if we start to search for a new means and ways to produce and use our clothes, use different types of fibers, change the conventional and old farming practices, and wash our clothes in a different way. The paper is valuable to a wide range of interested groups. It is for the people in business who have to balance their personal ethics and their consumer's needs for their business to grow. It is for consumers who have a limited budget but are worried about the impact of their shopping choices. It is for campaigners and those in education, government and the media to try to provide as balanced evidence as possible about the present and future impacts of the textiles and clothing sector.
It tries to find the possibility for significant and lasting change by looking at what might happen if the textiles industries sectors were to experience a change.

Keywords: *toxic chemicals, pesticides and fertilizers, bio-fibers, synthetic fertilizers, nanotechnologies, biosciences*

المستخلص: هدفت هذه الورقة إلي النظر بتمعن للمتغيرات التي يمكن ان تحدث إذا تم تغيير طرق تصنيع واستعمال الملبوسات, استعمال شعيرات نسيجية جديدة, تغيير عمليات الزراعة التقليدية وتغيير طرق غسل الملبوسات.
تناولت الورقة احد المواضيع الهامة جدا لذوي الاختصاص والمهتمين بهذا القطاع (لرجال الأعمال لضمان ازدهار اعمالهم, للمستهلك لضمان الاختيار الامثل للمنتج, للمروجين للاعلانات التجارية, للعاملين في قطاع التعليم, للدولة, ووسائل الإعلام) لتقديم حقائق متوازنة عن االاوضاع الحالية والمستقبلية لقطاع المنسوجات والملبوسات. تم إعداد الورقة بحيث تعكس الاثار التى يمكن ان تنتج إذا تم حدوث تحول شامل لقطاع المنسوجات والملابس.

Introduction:

The clothing and textiles sector is a significant part of the world's economy. In 2007 the world's consumers spent around US $1 trillion on clothing split roughly one third in Western Europe, one third in North America, one quarter in Asia [(1)]. Seven per cent of total world exports are in clothing and textiles. Significant parts of the sector were dominated by developing countries, particularly in Asia, and above all by China [(1)].

Industrialized countries are still important exporters of clothing and textiles, especially Germany, Italy in clothing and the United States in textiles. Developing countries now account for half of the world textile exports and almost three quarters of world clothing exports. However, for some materials, processes or products, other countries have an important role [(2)].

Companies are facing three forms of pressure from their consumers: shareholder expectations, customer loyalty and ethical pressure. There is considerable evidence that consumer interest in 'ethics' is growing and so business interest in developing and managing 'Corporate Social Responsibility' is also growing.

Major environmental impacts in the sector related to energy use and use of toxic chemicals. Chemicals are widely used in the clothing and textiles sector as pesticides and fertilizers in cotton farming and for dyeing yarns and fabrics. Intense use of chemicals may be harmful to the natural environment, to employees working in the industry and, in extreme cases, to babies and children wearing finished garments.

The various possibilities that might lessen the demand of the sector for chemicals with undesirable side effects may include

the followings:

- Substitution of existing fibre sources with new or traditional alternatives.
- Direct means to reduce chemical demand with existing materials and processes through organic farming of cotton and substitution with less toxic chemicals.
- Implications of various potential and innovative 'smart functions' such as novel coatings that extend the life of a textile product, or reduce the number of times an item of clothing must be washed by increasing its resistance to stains or odors.

Textile products could be made with similar functions but from different fibres. Cotton is the most common natural fibre used for clothing, but natural fibres such as wool, linen and silk are also common and other possibilities include hemp, ramie, flax, jute, sisal and coir. At present, production of these fibres is falling while demand for cotton is steadily increasing, but cotton agriculture is chemically intensive and in the future less demanding alternatives may become more common.

There is also growing interest in 'bio-fibres' renewable, short life cycle fibres obtained in principle by agriculture. Examples of bio-fibres include bamboo, soy, algae, maize, agricultural waste and nettle.

World production of man-made fibres, like polyester, polyamide, polypropylene, polyacryl, acetate, cupro and viscose has increased in 2006. A smaller group of synthetic fibres like elastane, aramid and carbon fibres accounts for only a little more than one per cent of total man-made fibre production in 2006 [2]. The man-made fibre industry comprises the cellulosic and non-cellulosic fibres and yarns. Cellulosics include viscose, acetate and cupro. These fibres are regenerated from chemically treated cellulose, which is originally derived from pulp in nature. The non-cellulosic mostly called 'synthetic' fibres and yarns include acrylic, nylon and polyester. These are derived from polymers produced from simple chemicals primarily from petrochemicals [3]. The production of man-made and synthetic fibres is both energy-intensive processes.

To reduce the environmental impacts of producing these materials, attempts are being made to create alternative fibres from renewable materials. For example, novel man-made fibres of natural origin like Tencel® (lyocell) made from wood and Ingeo® (poly lactic acid) obtained from corn, have been developed [4].

According to the Organic Trade Association, "organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and management practices that restore, maintain and enhance ecological harmony" [5]. Organic cotton is defined as cotton that has been grown without any use of synthetic fertilizers, synthetic pesticides and defoliated by natural means [6, 7]. Interest in organic cotton is growing with increasing awareness of problems with higher soil toxicity and the harmful effects on workers and consumers from conventional pesticides and fertilizers [7].

However, the production of organic cotton is still less than one per cent of the total cotton production.

In the conventional cotton industry, pesticides are sprayed over the cotton crops, causing serious health problems to cotton workers and soil degradation [8]. Synthetic insecticides for cotton are associated with large-scale poisoning and deaths in producing countries. Organic

cotton production abolishes synthetic pesticides, but makes use of natural pest killers like beneficial insects and 'trap crops', to keep away harmful insects [9].

Water consumption is also a major environmental issue in connection with cotton production. The actual water consumption is in the range of 7,000 to 29,000 liters per kg of cotton fibres. This is at least 20 times higher than the amount of water used in the subsequent production of textile products (e.g. dyeing and finishing) [6]. Uncontrolled diversion of water for irrigation can have dramatic consequences as seen in the Aral Sea disaster [6]. See Figure 1.

At present, organic cotton is more expensive than conventional cotton; however, over time this difference may reduce. The Research Institute of Organic Agriculture claims to have found significant advantages of organic over conventional cotton in cotton farming in central India [10]. The number of pest management days needed per year was reduced by around 40%. The costs of fertilizers and pest management were significantly reduced [10]. A study of African cotton farming claims that organic cotton crop growing improves yields per acre, enhances soil fertility and enhances food security [11]. In 2004, a report from Greenpeace raised awareness of the presence of hazardous toxic chemicals in Disney clothes [12]. Many of the manufacturing processes used for fibres and yarn, for instance in pre-treatment, dyeing and printing, are chemically intensive. However, these substances can be avoided. According to the Danish Environmental Protection Agency (EPA) [13], for all uses and in all circumstances, a suitable less toxic alternative could be found.

Research in novel nanotechnologies and in biosciences is driving innovation in so-called 'smart functions' for clothing and textiles. These technologies are still largely at the development stage, but promise a range of methods to change the behavior of clothing and textiles in use – usually through application of a coating to existing fibres, yarns or products. Possible functions include variable insulation, improved resistance to water, or sensitivity to sunlight.

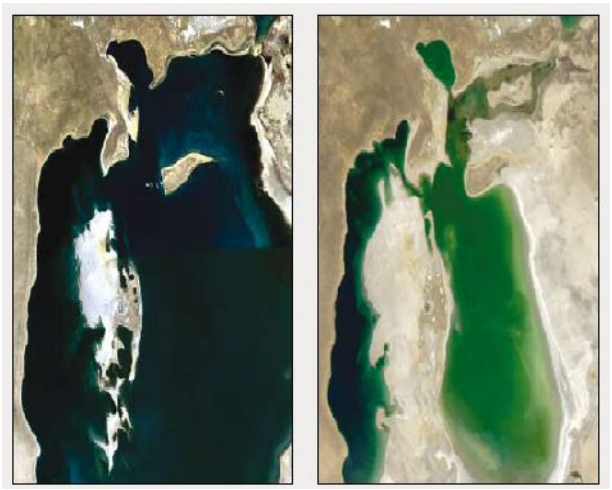

Figure 1: Aral Sea July / September 1989
Aral Sea August 2009

The base case environmental impact of textile products is dominated by the production of polyamide in the USA. Substituting this with wool from UK sheep leads to a significant drop in the combined environmental indicator, with a small increase in climate change impact mainly due to sheep releasing methane after digestion and an increase in waste (when extracting useful fibre from fleece) [4].

Switch to organic cotton with less toxic dyes causes a dramatic fall in the toxic impact of the product dominate the toxic impact of the cotton products, through its lifecycle but increase price.

The toxicity of clothes washing is not because the washing powder is particularly toxic or has low biodegradability but

primarily because a relatively large amount of detergent is discharged to biological waste water treatment, approximately 125g in the life cycle of the cotton product compared to only one gram of the finishing chemical [14].

Organic cotton is sold for 50% more in the USA than conventional cotton. All other economic measures in the world will improve assuming that consumers are willing to pay a higher price for organic cotton products.

The invention of an application that would double the life span of a product would reduce all global environmental measures. The production phase of the life cycle of the product dominates the use phase. Thus as the rate of new product production is halved, the impacts are nearly halved even though the introduction of nanotechnology in the production of polyamide fibre may increase consumption and emissions.

Reducing the rate at which we wash our clothes is beneficial. The application of "smart technology" that halves the number of washes in the life cycle of the product is also beneficial. Introduction of an "easy care" process during the finishing stage of production will increase the energy consumption for this process.

Despite this, the benefits from the reduction in laundering will reduce the overall environmental impact depending on the category. One limitation of this analysis is that there is yet very little evidence available about the environmental and health impact of nanotechnology, so the toxicity impact of the 'easy-care' process is not yet clear. However, it is likely that the toxicity impact of conventional cotton growing and harvesting would still dominate. For a product produced from organic cotton, the toxicity of the imagined nanotech treatment would be proportionately more significant.

For the end-consumer, the effect of reducing the number of washes will be to reduce the need for electricity, water and detergent. The market for laundry detergents in the world has been over supplied for the past 10 to 15 years, so laundry liquids are sold at similar prices to 20 years ago and about 80% of all laundry liquids are sold at a discount [15]. The consumer will therefore see little benefit from washing less, despite rising energy prices [16]. This theme raises the possibility that significant changes could be made in the sustainability of the clothing and textiles sector through changes in material sourcing and technology innovations. However, would consumers want to adopt these changes?

Interest in the environment among consumers has been growing in recent years and more people are becoming aware of green alternatives to regular products [17]. However, just by looking at the product, it is difficult to see whether it has been made from conventional or organic cotton, dyed with non-toxic or harmful dyestuffs. Therefore, a class of labels is being introduced with requirements that manufacturers must meet before they can call their products 'green'. For example, organic certifications from the Soil Association and regional and global eco-labels may be shown on products that meet these requirements [18]. Widely recognized eco-labels are helpful guidelines for consumers who want to buy eco-friendly products.

There is increasing discomfort among consumers about 'scientifically proven' innovations. In addition, smart clothing and textiles have intelligent properties, but are more expensive than regular clothing. A trade-off exists between paying a bit more for a product that claims to last longer, and paying the same price for a product of familiar quality. Some people do not have a

choice about wearing smart clothing: for protective clothing during their work, or sports that require breathable but strong fabric. The smart clothing market has grown significantly and is broadening its scope after having proved its value in these specific areas. In order to provide confidence in the claims made for new technologies, some manufacturers, for instance, offer ten-year wear warranties.

By exploring of the impacts of new products and materials, it is possible to note that:

- The extensive use of pesticides in conventional cotton crop growing is a major environmental issue.
- Using organic cotton would significantly reduce the life-cycle toxicity of cotton products. This fact may therefore suggests that recycling or reuse of cotton product (in order to reduce the demand for new virgin fibres) would have great value not only for energy saving (as with synthetic materials) but to reduce the use of toxic chemicals.
- The value of nanotechnology or 'smart functions', depends on whether it acts to reduce the dominant impacts of a product's life cycle. Their adoption, once scientifically proven, will depend on consumer trust and acceptance

Substituting natural fibres for synthetic fibres may be a useful move and of a significant benefit in the general environmental indicator, but a slight worsening of the climate change indicator.

Adoption of organic cotton in clothing, and increased use of wool (as opposed to polyamide) depends on consumers asserting that they will pay more for a more 'ethical' product. The toxicity impact of other chemicals used in the production of conventional cotton is not significant compared to those used in agriculture.

A benefit of the opening-up of markets has been an increased global awareness of poor labour practices and environmentally damaging actions in some parts of the global clothing and textiles industry. This awareness has in some cases led to development of new ethical and environmental standards. Eco-labels, which aim to set environmental standards for products assessed by governmental bodies, may in fact become the new trade barriers whereby retailers and consumers in developed countries can enforce standards on their suppliers. There is some concern that eco-labels could be used as unfair trade barriers, since the standards often favor the current standards of the imposing territory (for example the European Union) and therefore give an advantage to internal producers [19].

However, the opportunity to use such labels to bring about social and environmental improvement is attractive even though the change is likely to lead to higher consumer prices. At an industry level, companies are increasingly developing ethical standards for good practice. They are at least partially driven by negative publicity and campaigning and are concerned to ensure that realistic standards are achieved in practice.

A common thread is the importance of the consumer behavior in creating a change in the sector. To reduce the environmental impact of the sector, the consumers should reduce the amount of clothing and textiles they purchase each year.

Almost certainly, this behavior would appeal to only a small minority of consumers and would have economic and social disadvantages elsewhere.

Therefore, in order to promote the best environmental and social performance of the supply of clothing and textiles, the consumer should;

- Buy second-class clothing and textiles where possible.

- Buy fewer but longer lasting garments and textile products.
- When buying new products, choose those made with least energy and least toxic emissions.
- Wash clothes less often, at lower temperatures and using eco-detergents, hang-dry them and avoids ironing where possible.
- Extend the life of clothing and textile products through repair.
- Dispose of used clothing and textiles through recycling businesses who would return them for second-hand sale wherever possible, but otherwise extract and recycle the yarn or fibres.

If consumers chose to behave in this way, both government and business would follow their behavior and provide the services and functions they demanded.

However, apart from consumer inertia there are several reasons why the consumer behavior described above is not current. These reasons could be summarized as follows;

- In a wealthy society, clothing and textiles are bought as much for fashion as for function, and the desire to appear fashionable promotes purchase of products before the end of their natural life.
- Longer lasting clothes made with environmental and social responsibility will cost more than those made without such consideration.
- Consumers do not necessarily recognize the connection between their purchase and use of clothing and textiles and their environmental and social consequences.
- The benefit of the 'ideal' behavior depends on collective not individual behavior but it is much more difficult to create a mass changed of direction than to motivate a few pioneers taking in the account the following important factors:
- Repair is currently an expensive service.
- The rapid rise of 'fast fashion' in the past five years has increased the flow of material in the sector, but with the expectation that garments will be worn fewer times before disposal. These garments may be less easy to repair than higher quality products.
- Generally, clothes are washed in order to 'freshen' them (remove odour) rather than to remove stains, but do not have a 'freshening' process other than washing – which is necessary for stain removal.

The four major groups that can influence change in this sector are consumers, government, business (primarily retailers) and "information providers" (educators, campaigners, journalists and academics). Rather than trying to provide a prescriptive menu of actions for each group, a set of actions that would support a move towards the ideal consumer behavior could be proposed.

For consumers, the motivation to take purchasing decisions based on environmental and social concerns is complex as the consequences of an individual purchasing decision are relatively small and also apparently remote. Consumer education is therefore vital to ensure that fact based information on the individual impacts of a product are made clearly available and then to support consumer understanding of the consequences of this information. Eco-labels are a step towards this goal and development of well-grounded information through eco-labels is a necessary step.

However, in addition, consumers need support in understanding the link between a product's hidden use of resources and its consequent harmful impact (as seen dramatically in the Aral Sea), or as

predicted with global warming. Such education can be funded by government, promoted by business and driven further by campaigners and educators.

The complex set of interactions which contribute to 'fashion leadership' by which certain styles are seen to be current could actively promote durability as a component of fashion. The idea of 'design classics' is well understood and many cycles of fashion return to styles of the past. Increased emphasis on durable style would support consumers in moving towards purchase of fewer higher quality and longer lasting products.

Reducing the flow of existing products purchased in the country would directly reduce the employment and income generated by the sector. However, raw material costs in this sector are proportionately low. Therefore, if half the material mass was used to create half the current number of products, with higher quality material inputs and double the labour input for each item, the sector could halve its material flow without economic loss provided that consumers are prepared to pay a higher price for a product that lasts twice as long.

New business models with growth in profit decoupled from increased material flow are possible where consumers pay for services such as repair, novel coatings, other maintenance services, remanufacturing or 'fashion upgrades' rather than for purchase of new 'virgin' material.

There is great scope for technology development to support a move to reduced the impact such as:

- New means to freshen clothes without washing would be advantageous.
- Fibre recycling technology has had relatively little attention in the past years, but it has a significant scope both for extracting fibres with less shortening and for fibre separation from blended products,
- Development of detergents will allow further reductions in wash temperatures.
- Novel coatings and smart functions may support increased product life and reduced need for care in use, although they may also impede material recycling.
- New longer lasting fibres would support durability.
- The infrastructure of clothing collection could be greatly improved. For example, domestic waste sorting could allow separate collection of used clothing and textiles (as increasingly happens with glass and paper).
- An eco-tax on new product purchase could be used to slow the growing rate of material flow in the sector and fund development of technology, infrastructure and services for clothing and textiles recycling.
- Legislation could be used to outlaw specific undesirable components – such as particular toxic chemicals, but this would be difficult to impose on imports due to the complex range of chemicals involved.

However, the key to change remains the behavior of the mass of consumers so the role of educators and campaigners in raising awareness of the consequences of consumer choices is the main gear for driving change.

Conclusion:

The largest part of the work in this paper was a wide-ranging analysis of various possible futures for our clothes. The analysis included prediction of the environmental, economic and social consequences of changes in production structure, consumer behavior, material and process innovations and government influence.

The main findings can he summarized as follows:

- Improvement in the environmental performance of the sector is material specific and depends on the energy and toxicity life-cycle profile of the material.
- For conventional cotton products, the requirement for energy is driven by laundry, but the use of toxic chemicals is driven by agriculture.
- For products in which production dominates impacts, process efficiencies should be pursued and the impact will be reduced by extending the life of the product or by re-using materials by some form of recycling.
- For products in which raw material production dominates, in addition to measures to extend product life, alternative processes or materials should be pursued. A switch from conventional to organic cotton growing would eliminate most toxic releases, at the cost of price rises.
- Energy requirements for cotton garments are dominated by washing, drying and ironing. In response, wash temperatures can be reduced and tumble-drying avoided. Novel treatments may provide resistance to odors so reducing the total number of washes or allow faster drying with less ironing.
- Recycling is significant for materials with high impacts in the production phase. Technology innovations may provide a means to extract longer fibres from used textiles, although a recent innovative business for carpet recycling failed to achieve profitability.
- The globalized structure of the clothing and textile supply chain does not have significant environmental disadvantage, as energy used in transport is proportionately low.
- Technology innovations such as 3D knitting and weaving may lead to economically viable production, with some consumer benefits from increased responsiveness. However, this will only have environmental benefits if associated with material recycling.
- Change in the sector to reduce environmental impact and promote social equity will occur if driven by consumer choice.

References:

1. Andreas Engelhard, (2005), Textiles Intelligence, 'World-wide and regional trends in man-made fibre production', Technical Textile Markets. 2nd quarter.
2. Textiles Intelligence, (2005), 'Prospects for India's Man made Fibre Industry'. Technical Textile Markets, 2nd quarter.
3. Lyocell Tencel a fibre made out of beech wood, 100% biodegradable. www.lenzing.com/group/en/774.jsp and www.lyocell.net Ingeo a fibre developed from PLA polymer by Nature Works. www.ingeofibers.com/ingeo/home.asp
4. British Wool Marketing Board. Fact sheet 4. www.britishwool.org.
5. The Organic Trade Association-The Organic Pages Online. Helps users to find certified organic producers and products and serves as a reference for the organic community.
6. www.theorganicpages.com
7. D. Myers and S. Solton. 'Organic cotton: From field to final product'. August 2002.
8. www.panuk.org/new%20site/Projects/ Cotton/Resources/ book.html.
9. Simon Ferrigno, (2002), Pesticide action network UK, 'Moral fibre: a beginner's guide to the UK market', A report for PAN UK's pesticides poverty and livelihoods project.

10. www.pan-uk.org/
11. Simon Ferrigno, (2005), Pesticide action network UK 'Moral fibre: a beginner's guide to the UK market'.
12. Laursen, S.E., Hansen, J., Bagh J., Jensen, O.K. and Werther, I. (1997). "Environmental assessment of textiles. Life cycle screening of the production of textiles containing cotton, wool, viscose, polyester or acrylic fibres." Environmental project no. 369. Ministry of the Environment and Energy. Danish Environmental Protection Agency.
13. Eyhorn F., Maeder P., Ramakrishnan, M. (2005), 'The impact of organic cotton farming on the livelihoods of smallholders'. Evidence from the Maikaal bioRe project in central India.
14. Peter Ton. (2002), 'Organic cotton production in Sub-Saharan Africa'.
15. Henrik Pedersen and Jacob Hartmann, (2004). 'Toxic children's wear by Disney- a worldwide investigation of hazardous chemicals in Disney clothes'. For Greenpeace, Brussels
16. The Danish Environmental Protection Agency.
17. www.mst.dk/homepage/developingcountries
18. DHI Water & Environment and dk-teknik energy & environment. (2003), European eco-label. 'Revision of eco-label criteria for laundry detergents' final report. ec.europa.eu / environment / ecolabel / pdf / laundry_ detergents / finalreport_0503.pdf
19. Energy Watch, (2003), 'Rising Energy Prices'. Explains the UK rapid increase in energy prices since October. www.energywatch.org.uk/
20. Keith Walley, Paul Custance, Stephen Parsons. Harpen Adams, (2008), Research article: UK consumer attitudes concerning environmental issues impacting the agri-food industry. University
21. College, Newport UK. www3. Inter-science .wiley. com/cgi-bin/abstract/75500542/ ABSTRACT
22. Official Journal of the European Committees, (2002), Commission decision: establishing the ecological criteria for the award of the Community eco-label to textile products and amending Decision 1999/178/EC.
23. Eco-labels as trade barriers? These and more questions discussed on the effects of trade distorting legislation. www.wto.org/
24. Global eco-labelling network (GEN) (2004), 'Introduction to eco-labelling', Information paper. www.gdrc.org/sustbiz/green/gen-infopaper.pdf
25. The Oeko Tex International standard. www.oeko-tex.com/en/main